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Indian Standard

METHODS OF MEASUREMENTS ON TELEVISION PICTURE TUBES

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INDIAN STANDARDS INSTITUTION

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

Gr 5

August 1968

Indian Standard

METHODS OF MEASUREMENTS ON TELEVISION PICTURE TUBES

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Indian Standard

METHODS OF MEASUREMENTS ON TELEVISION PICTURE TUBES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 22 April 1968, after the draft finalized by the Electron Tubes and Valves Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The object of this standard is to lay down uniform and repeatable procedures for carrying out measurements on the following basic parameters of television picture tubes:

a) Stray emission,

b) Flash-over,

c) Screen centre focusing voltage,

d) Spot diameter,

e) Useful screen dimensions,

f) Gas content coefficient,

g) Cut off voltage,

h) Electrode leakage current,

j) Heater cathode leakage current,

k) Picture tube capacitances,

m) Screen-luminance, and

n) Large area contrast.

0.3 The system for television broadcasting in India having been finalized, the time was considered opportune to take up work on this subject with a view to guiding the industry through proper lines.

0.4 Assistance has been derived from the following documents while preparing this standard:

39 (Central Office) 133 Measuring method of stray emission and flash-over in television picture tubes. International Electrotechnical Commission.

39 (Central Office) 163 Methods of measurement for television picture tubes—screen centre focusing voltage, spot diameter, useful screen dimensions, gas content coefficient. International Electrotechnical Commission.

39 (Central Office) 179 Methods of measurement for television picture tubes: Spot diameter. International Electrotechnical Commission.

ASA C60.15-1963 Methods of testing electron tubes. United States of America Standards Institute.

0.5 This standard is one of a series of Indian Standards on electron valves and tubes.

0.6 In reporting the results of measurements on television picture tubes made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard lays down procedures for measuring the basic parameters of monochrome television picture tubes.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Stray Emission — The emission that causes a luminance of the screen in a picture tube operated under cutoff conditions.

2.2 Flash-Over — An uncontrolled discharge between any two or more tube elements.

2.3 Screen Centre Focusing Voltage — That voltage on the focusing electrode of the tube that gives the best focus of a defined pattern at the centre of the screen at the specified operating condition.

2.4 Spot — The small area of the screen surface instantaneously affected by the impact of the electron beam.

2.5 Spot Diameter

a) The apparent diameter of the spot when viewed through a microscope under specified operating conditions. This diameter corresponds to the diameter of the area bounded by 20 percent of peak luminance as estimated by the eye.

*Rules for rounding off numerical values (*revised*).

b) The apparent diameter of the spot when viewed through a slit which is scanned across it. This diameter corresponds to the distance between lines bounded by 20 percent of peak luminance (*see* Fig. 1).

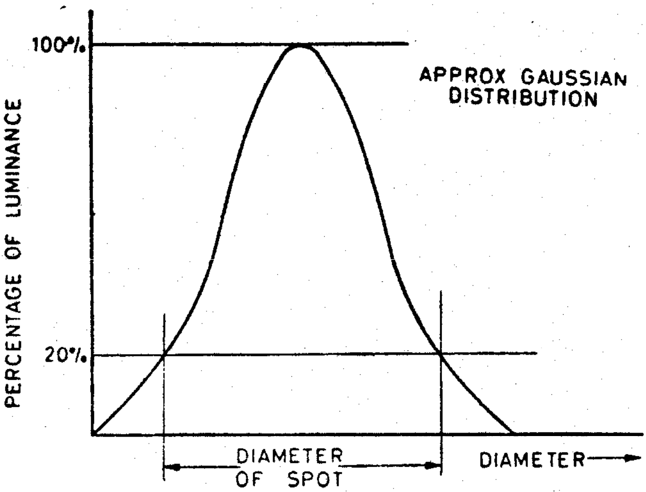

FIG. 1 LUMINANCE DISTRIBUTION

2.6 Useful Screen Dimensions — The dimensions of the luminescent part of the screen visible when viewing in the direction of the tube axis.

2.7 Gas Content Coefficient — The ratio of the ion current to the electron current which causes it.

2.8 Candela — The unit of luminous intensity. Its magnitude is one sixtieth of the luminous intensity of one square centimetre of a black body radiator operated at the temperature of solidification of platinum.

2.9 Lux Lumen per Square Metre — SI unit of illuminance: Illuminance produced by a luminous flux of 1 lumen uniformly distributed over 1 square metre.

Symbol: lx

Other units:

Metric: phot (ph) = 10^4 lx

Non-metric: foot-candle (fc) or lumen per square foot (1 lm ft^{-2}) = 10·764 lx

2.10 Luminance (at a Point of a Surface in a Given Direction) — The quotient of the luminous intensity in the given direction of an infinitesimal element of the surface containing the point under consideration, by the orthogonally projected area of the element on a plane perpendicular to the given direction. The unit is cd/cm².

2.11 Nit — Unit of luminance and is equal to a luminance of one candela per square metre.

2.12 Large Area Contrast — The ratio of luminance at two widely separated areas on the screen with the screen excited by the electron beam, to a particular luminance level in one of the two areas, and with the beam biased off in the other area.

2.13 Detail Contrast — The ratio of the values of luminance of adjacent picture elements and is intimately associated with resolution.

3. GENERAL PRECAUTIONS

3.0 General electron tube precautions specified in IS : 4147-1967* are applicable in addition to those given in **3.1** to **3.5**.

3.1 Insulation — In testing the picture tubes insulation and spacing shall be provided in the test equipment to prevent arcing and leakage that may change the operating conditions imposed on the tube or give false current readings. In general, cathode-ray tubes are operated so that those electrodes upon which the highest frequency signals are impressed are at or near ground potential. The picture tubes are commonly operated with the cathode or control grid at ground potential.

3.1.1 Leakage currents and charges on the external surface of the tube can produce spot shifts and distortion of the screen patterns. One method of reducing these effects is to test the tube with the screen near ground potential.

3.2 Safety Precautions — In testing picture tubes, care should be taken to ensure that the operator is protected against high-voltage shock, X-ray exposure, and tube implosion.

3.3 Operating Conditions

3.3.1 *Applied Voltages* — The various voltages shall be applied in such sequence as to prevent tube damage. In applying the voltages, care should be taken to ensure that the maximum rated voltages between electrodes are not exceeded. The control electrode voltage should always be of such value as to prevent screen burning during testing.

3.3.2 *Focus* — Improper focus adjustment of TV picture tubes may result in misleading data on such items as luminance and chromaticity.

*Methods of measurements on conventional receiving electronic valves.

The focusing field should therefore be adjusted for the desired focus, depending upon the type of measurement being made.

3.4 Electrode Currents — When making certain electrode current measurements, in particular, the zero-bias cathode current, care should be taken to prevent burning of the screen or damage to limiting apertures as the result of excessive heating. The screen may usually be protected by using a full raster scan or defocusing the tube during measurement.

3.5 Metal base sleeves and external conductive coatings should be grounded for all tests unless otherwise specified.

4. STRAY EMISSION

4.1 Measuring Conditions

4.1.1 The tube being measured should be placed in a given circuit, with stated voltages including a luminance cut-off voltage and a deflection voltage applied.

4.1.2 The ambient illumination should not exceed 5 lux when measured at the screen of the tube.

4.1.3 The observer should have accommodated his eyes to viewing the screen of the tube.

4.2 Measuring Result — The measuring result is a statement whether or not a luminance is visible within a given time of 5 seconds.

5. FLASH-OVER

5.1 Method A

5.1.1 *Measuring Conditions* — The tube should be placed in a given circuit with stated voltages applied.

5.1.2 *Measuring Result* — The measuring result is the number of flashes observed on the face of the tube during a given time of 10 seconds.

5.2 Method B

5.2.1 *Measuring Conditions*

5.2.1.1 The tube should be placed in a given circuit with stated voltages applied. This circuit should include a defined impedance in the cathode lead and a counting device suitable for counting the voltage pulses which develop over the cathode impedance as a result of flash-over.

5.2.1.2 The characteristics of the counting device (input impedance, sensitivity, time discrimination between successive pulses) should be given.

5.2.2 *Measuring Result* — The measuring result is the number of flashes counted during a given time of 10 seconds.

6. SCREEN CENTRE FOCUSING VOLTAGE

6.1 General — In a television picture tube, the distance between the deflection centre and the screen varies from the centre of the screen towards the edges, resulting in some deflection defocusing. Thus the spot correctly focused at the centre of the screen may show some defocusing when it is deflected to other places on the screen. Therefore, a specified focusing point on the screen and a defined pattern are necessary to determine a particular focusing voltage.

6.2 Measuring Method

6.2.1 *Measuring Conditions*

6.2.1.1 The tube to be measured is placed in a defined circuit including deflection system, with specified voltages applied. A suitable single voltage to obtain a defined pattern is applied to the modulation electrode. The beam current (final electrode current) is adjusted to the specified value after thermal equilibrium conditions are reached. As an alternative, measurements can be made on a pulsed spot.

6.2.1.2 The ambient illumination, measured at the screen of the tube, should not exceed 5 lux.

6.2.2 *Measurement* — The voltage on the focusing electrode is adjusted to obtain the best focus of the pattern at the centre of the screen.

6.2.3 *Measuring Result* — The measuring result is the voltage on the focusing electrode obtained under the above conditions.

7. SPOT DIAMETER

7.1 General — The measurement should be carried out with a pulsed signal on the modulation electrode. The pulsed signal should have a specified duration, repetition frequency and waveform. The luminance measured along the spot diameter, varies with the diameter and the pulsed signal characteristics. In general, the luminance distribution with a substantially rectangular pulsed signal is given in Fig. 1.

7.2 Measuring Conditions

7.2.1 The tube to be measured is placed in a defined circuit with specified voltages applied, without deflection and without correction magnets. The beam current should be adjusted to a stated value.

7.2.2 The ambient illumination, measured at the screen of the tube, should not exceed 5 lux.

7.2.3 The tube should be biased to luminance cutoff.

7.2.4 A specified pulsed signal is applied to the modulation electrode, the following pulse characteristics being stated:

a) Amplitude,

b) Repetition frequency,

c) Duration, and

d) Rise and fall times.

7.3 Measuring Methods

7.3.1 *Microscope Method* — The observer should have accommodated his eyes to the illumination before viewing the screen of the tube. The spot is viewed through a microscope fitted with a suitable graticule by means of which the observer estimates the diameter of the spot.

7.3.2 *Movable Slit Method* — A movable metal plate, having a slit whose width should not exceed 10 percent of the spot diameter and which has fixed dimensions and a stated orientation, is coupled to a micrometer and is placed in front of the luminous spot. A light-sensitive instrument is placed immediately behind the slit, and the slit is moved across the spot by means of the micrometer. The distance between the points where the deflection is 20 percent of the maximum deflection given by the light-sensitive instrument is read directly on the micrometer. This distance gives the apparent spot diameter.

7.4 Precaution — To prevent screen burning it is essential that the measurement is carried out with a pulsed signal.

8. USEFUL SCREEN DIMENSIONS

8.1 Measuring Method

8.1.1 *Measuring Condition* — During the measurement the tube is operated in such a way that a raster is produced exceeding the screen dimensions.

8.1.2 *Method of Measurement* — The dimensions can be read on a measuring device consisting of a viewer which can be shifted along a calibrated scale. The viewer should give parallax free readings.

8.1.3 *Measuring Results* — The measuring results are the dimensions of the luminescent part of the screen obtained under the condition of measurement. The dimensions should be given as maximum height, maximum width and maximum diagonal.

9. GAS CONTENT COEFFICIENT

9.1 General — The actual value of the gas content coefficient (G) is partly dependent on the electrode structure of the tube; different types of tube may give different values of G although the absolute gas pressure may be the same in each case.

9.1.1 The current I measured in the ion collecting electrode circuit of Fig. 2 (meter A_1) consists of an ion current (I_1) and a leakage current (I_2). The leakage current (I_2) (meter A_1) can be measured separately under cathode current cut-off conditions.

9.1.2 The ionizing current is the current I_3 measured in the cathode circuit (meter A_2). Typical values of the ion current are of the order of a few nanoamperes.

The gas content coefficient is: $G = \frac{I_1}{I_3} = \frac{I - I_2}{I_3}$

NOTE — This method is not applicable to triode gun tubes.

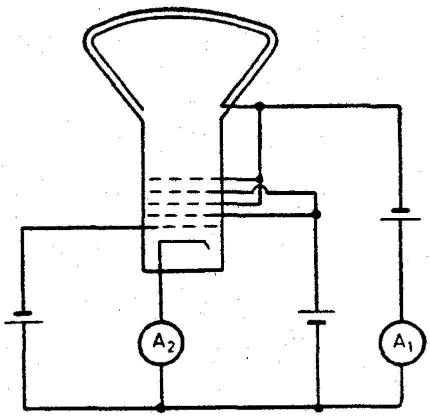

FIG. 2 CIRCUIT FOR THE MEASUREMENT OF GAS CONTENT COEFFICIENT

9.2 Method of Measurement — The current I and I_3 in condition 1, and I_2 in condition 2, are measured in the basic circuit shown in Fig. 2. In the conditions 1 and 2 the ion collecting electrodes should be the most negative electrodes in the tube.

9.2.1 *Condition 1* — The tube is placed in the circuit shown in Fig. 2 with stated voltages applied. Grid number 1 is biased to produce a stated cathode current (I_3) (usually in the order of some hundred

microamperes). The voltage on grid number 2 is sufficiently high to cause ionization of the gas (approximately 250 V). The anode and the electrodes strapped to the anode are connected to a negative voltage to collect the ions. This voltage should be sufficiently negative to prevent electrons from reaching the anode (approximately 25 V).

9.2.2 *Condition 2* — As condition 1, except that grid number 1 is biased to obtain cathode current cutoff condition.

9.3 Measuring Result — The measuring result is the ratio of the values ($I - I_2$) and I_3. The units of the currents in the numerator and denominator should be stated.

10. CUTOFF VOLTAGE

10.1 Luminance-Cutoff Voltage — The luminance cutoff voltage is determined by measuring the modulation electrode control electrode bias voltage for visual extinction of the undeflected focused spot or the scanned raster. Since these values will in general be different, the method of determination of the cutoff voltage (that is, spot or raster) should therefore be specified. The ambient illumination at the tube screen should be kept at such a low level that further reduction will not affect the measured value. In measuring spot cutoff, the viewing distance, the use of optical instruments for viewing the spot or the extent of dark adaptation of the observer may affect the measured value.

10.2 Current-Cutoff Voltage — The current-cutoff voltage is determined by measuring the modulation electrode (control electrode) bias voltage required to reduce the cathode current to some specified low value, usually about 1 μa or less.

11. ELECTRODE LEAKAGE CURRENTS

11.1 Leakage currents are the undesired currents which flow between the electrodes when voltages are applied to those electrodes with the electron beam cutoff.

11.2 Most leakage currents can be conveniently determined by applying all the specified electrode voltages and reading the currents in external circuits with the control electrode bias set at a specified value beyond cutoff. These currents are identified by the circuits in which they are read.

11.2.1 If the tube application normally required substantial resistance in external circuits, it is desirable in the measurement of tube leakages to include an appropriate amount of resistance in the circuit, since measured values of the leakage without added circuit resistance may not correlate with performance in the intended application.

12. HEATER-CATHODE LEAKAGE CURRENT

12.1 This measurement shall be done in accordance with **5.4** of IS : 4147-1967*.

13. PICTURE TUBE CAPACITANCE

13.1 General—The direct interelectrode capacitances to be measured in a particular cathode-ray tube are usually listed in the individual data sheet. In general practice the following capacitances are the most important, because high frequencies are most likely to be applied to these elements:

a) On all types, the capacitance between control grid and all other elements tied together; and

b) On types with heater and cathode not internally connected, the capacitance between cathode and all other elements tied together.

The capacitance between the internal and external conductive bulb coatings is also usually specified.

13.2 Measurement of Direct Interelectrode Capacitances—For circuits, general precautions and measurements for interelectrode capacitances, reference may be made to **7** of IS : 4147-1967*.

13.3 Measurement of Capacitance Between Tube Coatings—Internal and external conductive coatings in portions of the bulb wall form a capacitor whose dielectric is the glass of the bulb. The high-frequency measurement of this capacitance is complicated by the fact that coatings have resistance. Because of this, the measured capacitance falls off at high frequencies and increases with increase in number of contact points to the coating. It is, therefore, desirable that data on capacitance of the tube coatings include the test frequency and the method of connecting to the coating.

14. SCREEN LUMINANCE

14.1 General—The screen luminance shall be measured by means of a suitable photometer. Instrumentation required and calibration of the photometer are detailed in Appendix A.

14.2 Measurement

14.2.1 *Tube Operating Conditions*—The operating conditions are adjusted in accordance with the published data for the particular

*Methods of measurements on conventional receiving electronic valves.

cathode ray tube under test. Particular attention should be given to the conditions listed below:

a) The tube should be operated with a sharply focussed beam that is scanning a raster at the specified line and frame frequencies;

b) Raster linearity should be carefully adjusted throughout the screen area;

c) Vertical retrace blanking should be employed; and

NOTE — Frequently, it is desired to measure power input to the cathode ray tube at the same time that the screen luminance is being measured, in order to compute screen efficiency. If the method of measuring screen luminance desired here is used, in which vertical retrace blanking is employed, it should be remembered that the current to the screen is not continuous but is actually pulsating because of the presence of the vertical retrace blanking. Suitable metering should be employed to measure the average value of this pulsating current.

d) The raster should be carefully adjusted to a specified size.

14.2.2 *Screen Luminance* — Using a calibrated visual photometer, the tube is adjusted to the specified working conditions and screen luminance measured. An average of several readings taken by an experienced observer should be used for each luminance level.

When numerous readings on tubes of the same type are required, a physical photometer may be used to gain a higher degree of repeatability with a minimum of operator variation. After a tube is measured by the visual photometer, it may be used as a secondary standard for physical photometers. The reading obtained from a physical photometer at a given fixed distance from the tube will calibrate the photometer for other tubes of the same type at the same luminance level if the operating conditions of the secondary standard are the same as those used during its measurements.

It should be stressed that calibrations of physical photometers by a secondary cathode ray tube standard may be valid only on tubes of the same type and when all of the conditions listed in **14.2.1** are duplicated.

14.2.3 *Stray Emission Luminance* — With the tube operating in accordance with its published data, with the control grid biased beyond cut-off and with the scan adjusted to stated test conditions, the luminance of the screen due to stray emission is measured. Since the luminance caused by stray emission will, in general, be at a very low level, even a very small amount of ambient illumination will affect the measurement.

14.2.4 *Cathode Illumination* — With the specified heater potential applied and with all other electrode voltages zero, the luminance of the screen due to light from the cathode is measured. Since the luminance

caused by light from the cathode assembly will, in general, be at a very low level even very small amounts of ambient illumination will affect the measurement.

15. LARGE AREA CONTRAST

15.1 General

15.1.1 Subjective evaluations of cathode ray tube displays, including not only television picture tubes, but also radar and oscilloscope tubes, show that the utility of the display and the amount of information which can be obtained from it are directly related to the degree of contrast that can be obtained from the cathode ray tube. Low contrast ratios reduce the number of individual luminance levels discernible in the display, and so reduce the amount of information obtained from the display.

15.1.2 The large area contrast of a picture tube is affected by many factors, and widely differing values may be obtained for any given tube depending upon the conditions of measurements. The large area contrast of any given tube is not necessarily uniquely determined by the physical structure of the tube or the general electrical conditions under which it is operating at the time of measurement. Factors such as, raster size and shape, picture content, reflected light from objects external to the tube, chromaticity and luminance of ambient illumination influence large area contrast measurement. The large area contrast of a tube is also affected by the amount of light from the excited portions of the screen that reaches the unexcited areas, and by undesired excitation of the dark areas of the picture by stray electrons.

15.1.3 Picture content, such as relative shape, size, and location of excited and unexcited areas, greatly affects large-area contrast. For example, in Fig. 3A, where the screen is excited directly only at the centre, the large area contrast obtained will be considerably higher than in Fig. 3B, where the screen is excited everywhere except at the centre.

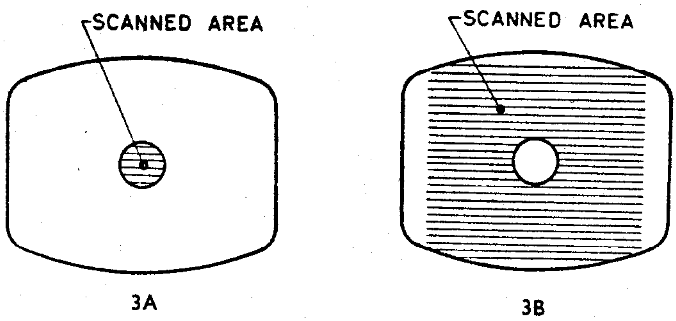

FIG. 3 RASTER SHOWING TWO TYPES OF LARGE AREA CONTRAST

15.2 Measurement — The method described here is for measuring large area contrast for comparison purposes only. The cathode ray tube is operated in accordance with its published data and with a scanned raster at the specified line and frame frequencies, and of normal height and only half normal width for the tube type under test. The raster is positioned with either the right or left edge passing through the screen centre (Fig. 4). The ambient illumination should be kept low enough so that any further reduction of the ambient illumination will not change the measurement.

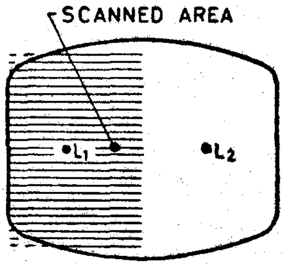

FIG. 4 RASTER USED FOR THE MEASUREMENT OF LARGE AREA CONTRAST

The large area contrast is given by the following formula:

$$\text{Large area contrast} = \frac{L_1 - LO_1}{L_2 - LO_2}$$

where

L_1 = luminance at position L_1 near the centre of the excited part of the screen,

LO_1 = luminance at position L_1 with beam biased off,

L_2 = luminance at position L_2 near the centre of the unexcited part of the screen, and

LO_2 = luminance at position L_2 with beam biased off.

The values of luminance L_1 and L_2 are measured with the grid bias adjusted for the desired raster luminance.

15.3 Precautions — The following precautions are significant:

a) The measurement will be greatly affected by the amount of over-scanning. It is important in comparing tubes that the raster be adjusted, as in Fig. 3, to just touch the top, bottom and one side of the viewing area of the tube with only the corners overscanned. If

measurements are made under other degrees of overscanning, the amount of overscanning must be specified.

b) The foregoing method of measurement is specified to be made with low ambient illumination because of the extreme difficulty of specifying and controlling all characteristics of the ambient light. However, it is recognized that picture tubes are normally used under conditions where the ambient illumination does not affect the large area contrast. It should be realized that measurements made under low ambient illumination may not correlate at all with measurements made under higher ambient illumination.

16. X-RADIATION — *under consideration.*

APPENDIX A

(*Clause* 14.1)

INSTRUMENTATION AND CALIBRATION

A-1. INSTRUMENTATION

A-1.1 Visual Photometers — Visual photometers, when properly used by a trained observer give accurate luminance measurements. However, they are subject to errors arising from:

a) poor colour match between screen luminous output and reference source;

b) colour-vision abnormalities of the observer; and

c) observer fatigue.

Marking measurements with visual photometers is tedious and fatiguing to the observer. Visual photometers are not therefore generally useful for routine production measurements of cathode ray tube luminance.

The outstanding advantage of a visual photometer for measurement of cathode ray tube is that it uses the human eye as the integrating device for the pulsating light output of the tube. Since the calibration standards for photometers are steady light sources, the interpretation of the standard source compared to the pulsating light sources such as the cathode ray tube is very important. A photometer that does not integrate the light in the same manner as the eye, may give erroneous results. With the visual photometer this proper integration is automatic since the eye is used as the integrating device.

A-1.2 Physical Photometers — Out of the four types of physical photometers, viz, photovoltaic type, photoemissive type, photoconductive type,

and thermopile type, photovoltaic type is the most widely used in industry because of its simplicity and stability. When used with an appropriate filter, usually available from the manufacturer of the photovoltaic cell, the spectral response of this type of photometer approximates that of the CIE relative luminous efficiency function.

A-2. CALIBRATION OF PHOTOMETERS

A-2.1 Calibration of Visual Photometers — Illuminate perpendicularly a uniform surface of known 45° 0° reflectance *R* with light from a standard lamp at a distance *D*, operated at the prescribed voltage to provide the rated intensity *I* in the specified direction.

NOTE — The 45° 0° luminance directional reflectance (for brevity called reflectance) is the ratio of the luminous flux from a specimen illuminated at an angle of 45° and viewed perpendicularly by the CIE standard observer to the luminous flux from the standard magnesium oxide layer, similarly illuminated and viewed.

The luminance *B* in a direction 45° from the perpendicular is computed as follows:

$$B = \frac{RI}{D^2}$$

When *I* is expressed in candelas, *D* in metres and *R* as a decimal fraction, *B* will be given in nits (cd/m^2). A sufficient number of distances must be chosen to provide luminance calibration over the desired range. Position the photometer, to view the centre of the surface, at an angle of 45° and at a sufficiently close distance so that the field of view is entirely filled by the illuminated surface. The instrument reading should not vary with change of distance to the surface and this condition should be verified experimentally.

Brightness matches are more readily made when the colours to be matched are similar; therefore, for improved accuracy the reference standard and the working standard lamp in the photometer should be altered by filters to a colour approximately that of the fluorescence of the phosphor to be measured. The colour correcting filter should never be used to alter the chromaticity of the source being measured.

A-2.2 Calibration of Physical Photometers — Physical photometers calibrated with steady light are subject to inaccuracies when used to measure pulsating light sources. Physical photometers when used to measure cathode ray tubes should, therefore, be calibrated by use of cathode ray tube operated at specified raster conditions and measured by means of a visual photometer.

Since the cathode ray tube, when displaying a raster, is a pulsating light source, and since the waveshape of the pulses is a function of many factors including size and shape of the raster, and the fraction of the

raster which the photometer views, phospher persistance characteristic, etc, the calibration of the physical photometer from a cathode ray tube as described above is completely valid only for use of the photometer under identical conditions of tube operating with the same tube type, same fraction of raster viewed, and with any other physical factors kept unchanged if the change of these factors affects the photometer readings.

If a visual photometer is not available for calibration of physical photometer, the physical photometer may be calibrated by means of a cathode ray tube screen luminance standard consisting of a standard lamp and filter combination.

Physical photometers calibrated by means of steady light sources may indicate erroneous values of luminance for cathode ray tube screens displaying rasters because the photometer and the human eye do not integrate the pulsating light of a cathode ray tube in the same manner. Therefore, when using a physical photometer calibrated by means of a steady light source to measure the luminance of a cathode ray tube screen displaying a raster, care should be taken to ensure that the pulsating light does not result in erroneous readings. For example, it has been found that extreme variations in raster size, or extreme variations in the percent of the raster which the instrument views may affect the readings of the instrument. If changes in such conditions are observed to produce unusual changes in instrument readings, the manufacturer of the instrument should be consulted as to the suitability of the instrument for measurements under the particular desired conditions.

The readings of physical photometers on pulsating light sources, such as cathode ray tubes may not be independent of the distance between the photometer and the light source. This has been found to be the case for certain physical photometers, where varying the distance between the photoreceptor and the cathode ray tube significantly changes the wave shape of the light pulses reaching the receptor.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 26 60 21, 27 01 31 **Telegrams : Manaksanstha**

Regional Offices:

		Telephone
Western : Novelty Chambers, Grant Road	BOMBAY 400007	6 32 92 95
Eastern : 5 Chowringhee Approach	CALCUTTA 700072	27 50 90
Southern : C. I. T. Campus	MADRAS 600113	41 24 42
Northern : B69, Phase VII	S.A.S. NAGAR (MOHALI) 160051	8 78 26

Branch Offices:

'Pushpak', Nurmohamed Shaikh Marg, Khanpur	AHMADABAD 380001	2 03 91
'F' Block, Unity Bldg, Narasimharaja Square	BANGALORE 560002	22 48 05
Gangotri Complex, Bhadbhada Road, T. T. Nagar	BHOPAL 462003	6 27 16
22E Kalpana Area	BHUBANESHWAR 751014	5 36 27
5-8-56C L. N. Gupta Marg	HYDERABAD 500001	22 10 83
R 14 Yudhister Marg, C Scheme	JAIPUR 302005	6 98 32
117/418 B Sarvodaya Nagar	KANPUR 208005	4 72 92
Patliputra Industrial Estate	PATNA 800013	6 28 08
Hantex Bldg (2nd Floor), Rly Station Road	TRIVANDRUM 695001	32 27